

Claims

What is claimed is:

546
B17
1. A device, comprising:

10007630-110901
a first fiber having a first untapered fiber section which is a single-mode fiber for light at a first wavelength and a first tapered fiber section which has one end conforming to and connected to said first untapered fiber section and has a fiber diameter gradually reducing from said one end to another opposing end; and

a second fiber having a second untapered fiber section and a second tapered fiber section which has one end being spliced to said another opposing end of said first tapered fiber section and another end conforming to and connected to said second untapered fiber section, wherein a fiber diameter of said second tapered fiber section gradually decreases from said one end to said another opposing end, and

wherein said second untapered fiber section is a single-mode fiber for light at a second wavelength and has a core diameter greater than a diameter of a fiber core of said first untapered fiber section.

2. The device as in claim 1, wherein each fiber has a structural variation from a respective untapered fiber section to a respective tapered fiber section that satisfies an optical adiabatic transformation condition to transform optical energy in a single mode in either of said first and said second untapered fiber sections in said first and said second wavelengths, respectively, into optical energy in a mode in said first and said second tapered fiber sections.

3. The device as in claim 1, further comprising an optical element located in an evanescent field of guided optical energy in one of said first and said second tapered fiber sections to evanescently exchange optical energy at said first wavelength with said first fiber and exchange optical energy at said second wavelength with said second fiber.

4. The device as in claim 3, wherein said optical element includes a micro cavity that supports at least one whispering gallery mode at said first wavelength and one whispering gallery at said second wavelength.

5. The device as in claim 4, wherein said micro cavity is in direct contact with a respective tapered fiber section of one of said first and said second fibers.

6. The device as in claim 4, wherein said micro cavity is spaced from a respective tapered fiber section of one of said first and second fibers.

7. The device as in claim 4, wherein said micro cavity is a sphere.

8. The device as in claim 4, wherein said micro cavity is not a sphere.

9. The device as in claim 3, wherein said optical element is located to evanescently receive light at said first wavelength received from said first untapered fiber section and to evanescently couple light at said second wavelength through one of said first and said second tapered fiber sections into said second untapered fiber section.

10. The device as in claim 9, wherein said optical element includes an optical cavity.

11. The device as in claim 10, wherein said optical cavity is a ring cavity.

12. The device as in claim 10, wherein said optical cavity is a Fabry-Perot cavity.

13. A device, comprising:

an optical fiber coupler having a tapered fiber section formed of a fiber cladding material to form an optical waveguide based on interfacing between said fiber cladding material and air, a first single-mode fiber for light at a first wavelength connected to a first side of said tapered fiber section, and a second single-mode fiber for light at a second wavelength connected to a second side of said tapered fiber section,

wherein said tapered fiber section has a structure to support at least one waveguide mode at said first wavelength and one waveguide mode at said second wavelength.

14. The device as in claim 13, wherein each of said first and said second single-mode fibers is connected to said tapered fiber section under an optical adiabatic transformation

condition to allow optical energy in a single mode in either of said first and said second single-mode fibers to transform into a waveguide mode in said tapered fiber section.

15. The device as in claim 13, further comprising a micro cavity that supports at least one whispering gallery mode at said first wavelength and one whispering gallery at said second wavelength and absorbs light at said first wavelength to produce light at said second wavelength, said micro cavity located relative to said tapered fiber section to evanescently receive light at said first wavelength from said tapered fiber section and to evanescently couple light at said second wavelength into said tapered fiber section.

16. The device as in claim 15, wherein said micro cavity is in direct contact with said tapered fiber portion.

17. The device as in claim 15, wherein said micro cavity is spaced from said tapered fiber portion.

18. The device as in claim 15, wherein said micro cavity is a dielectric material doped with rare-earth ions.

19. The device as in claim 15, wherein said micro cavity is a sphere.

B/cut. 20. The device as in claim 15, wherein said micro cavity is not a sphere.

21. A method, comprising:

splicing one end facet of a first fiber with a fiber core of a first core diameter to one end facet of a second fiber with a fiber core of a second core diameter different from said first core diameter to form a joint fiber device;

heating a section at or near a spliced location of said joint fiber device; and

stretching said joint fiber device under the heating to form a tapered region at and near said spliced location.

22. A method, comprising:

causing a pump beam at a pump wavelength to be coupled into a first fiber that supports a single mode at said pump wavelength;

causing said pump beam in said single mode to be transformed into a pump waveguide mode in a tapered fiber section that is connected to said first fiber;

10007630-110901

causing said pump beam to be evanescently coupled into an optical device;

causing light at a laser wavelength in said optical device to be evanescently coupled to a laser waveguide mode in said tapered fiber section; and

causing light in said laser waveguide mode to be transformed into light in a mode at said laser wavelength in a second single-mode fiber that is connected to said tapered fiber section to output said light.

23. The method as in claim 22, wherein said optical device is a micro cavity that supports at least one whispering gallery mode at said pump wavelength and another whispering gallery mode at said laser wavelength.

24. A device, comprising:

a tapered waveguide section to guide optical energy in at least one mode at a first wavelength and one mode at a second wavelength and to expose an evanescent field of said guided optical energy outside said tapered waveguide section;

a first waveguide section supporting a first single mode at said first wavelength connected to a first side of said tapered waveguide section to allow for conversion of optical

energy between said one mode at said first wavelength in said tapered waveguide section and said first single mode; and
a second waveguide section supporting a second single mode at said second wavelength connected to a second side of said tapered waveguide section to allow for conversion of optical energy between said one mode at said second wavelength in said tapered waveguide section and said second single mode.

25. The device as in claim 24, wherein one of said waveguide sections is formed of a fiber.

26. The device as in claim 24, wherein one of said waveguide sections is formed of a planar waveguide on a substrate.

27. The device as in claim 24, further comprising an optical element located to evanescently couple light at said first wavelength from said tapered waveguide section and to evanescently couple light at said second wavelength into said tapered fiber section.

28. The device as in claim 27, wherein said optical element includes an optical cavity.

B1/
cut

29. The device as in claim 28, wherein said optical cavity
is a whispering-gallery-mode cavity.

add B1

10007630-110901